Executive Summary:
MOWE-IT project has brought together the state-of-the-art knowledge of impact of extreme weather events and hazards on transport system. The 2-year project has utilised information from previously conducted research (EWENT, WEATHER and ECCONET projects as well as new analytical work performed by the consortium. The project has 12 partners, led by VTT, Technical Research Centre of Finland. The project aimed to produce high quality, visual guidebooks that would be able to disseminate the information available regarding improving resilience of transport networks. Additional deliverables of the project focused on exploration of cross-modality opportunities within Europe in greater detail as well as short-term measures to improve resilience and long-term policy guidelines. This analytical work was complemented by dissemination activities, ranging from website management to newsletters, resource materials collection and publication at the website and regional conferences to disseminate the project results.

Project results show that there is a lot that can be done and many lessons to be learned in terms of improving resilience, starting right now but more importantly over the time, as we have more accurate information about the impact of climate change. However, the general awareness of the public, operators and decision-makers is not particularly high on the matters of extreme weather resilience. This is shown by repeated patterns of activities in Europe, where year in and year out certain phenomena cause a disruption, despite their relative frequency. MOWE-IT project has tried to highlight these phenomena and also to suggest ways in which to deal with them. This project has focused on high visualization of the phenomena. Not only transport-mode specific guidebooks, but also a visualization tool was developed as one of the outcomes of the project. The interactive tool allows the user to specify the period in which he or she wishes to study travel options, mainly the switch from aviation to other transport modes (road/rail). The purpose is to show the ways in which early preparedness to potential disruptions can offer travel alternatives, if and when the passenger is aware of such options. Naturally there are at present limitations to such alterations in travel patterns, as changing from one transport mode or route to another most likely comes with a cost, if the already made arrangements need to be altered. However, this is perhaps a topic for discussion as a way forward in improving individual travellers resilience to disruptions.

In terms of infrastructure development, better planning is the key way forward. Events such as flooding, fog, snow, wind gusts etc. can
be to a large extent localised and the ways to mitigate them at areas of occurrence should be included in the planning. However, this requires that those in charge of the planning are aware of these events and the role they can play in operations of the planned infrastructure. Better collaboration between weather agencies and transport planners is therefore required.

Project Context and Objectives:
The European transport system has shown vulnerability to external shocks, which have partially or, in some cases, totally shut down part of the transport system. Particularly the aviation industry has been disrupted by natural disasters and extreme weather events, leaving other transport modes with no adequate plans and resources to deal with the responses required. The problem is complex by its nature, due to the fact that the networks operate interchangeably both passenger and freight transport but even more as there are no official coordination mechanisms that would enhance cross-modality substitution in the transport system. Any robust assessment of cross-modality potential should, as the starting point, address these issues and try to seek in what ways the dynamics of the European transport system can be better improved.

The goal of the MOWE-IT project was to identify existing best practices and to develop methodologies to assist transport operators, authorities and transport system users to mitigate the impact of natural disasters and extreme weather phenomena on transport system performance. The weather phenomena, their impacts and their magnitude have already been identified previously in the 7th Framework Programme project EWENT (Extreme weather impacts on European networks of transport). This research will also utilise information from other recent and on-going projects such as WEATHER. In general, what has been established through research so far is that extreme weather phenomena induce specific issues for each single transport mode. Similarly to extreme weather events, natural disasters can also be classified with respect to their likely impact on various transport modes. In addition, there are issues that are relevant to cross-modal approach, particularly to the management of logistics chains at the European level and more globally as well. This research intends to address via the concept of cross-modality the possibilities to shift between two or more transport mode for alternative travel/route options. Supply chains in freight transport, including multimodality, will be also investigated and reviewed. MOWE-IT addressed specific research questions in certain transport modes by identifying practical applications to manage transport networks more effectively in the future. MOWE-IT will also evaluate the possibilities to utilise technologies to create platforms, which can be aide to treat similar phenomena in other regions and climatic zones as well. Combination of latest technology available to transfer weather-related information with best accurate forecasting models will generate state-of-the-art solutions that benefit decision-makers, companies and transport infrastructure managers, operators and users. As problems related to each transport mode differ from one another, MOWE-IT focused on identifying the benefits for infrastructure users, operators, managers and decision-makers, wherever appropriate.

One of the crucial aspects of transport system is that actors and operators are interlinked, thus separate analysis of an actor or transport mode yield non-meaningful results as the interactions with other parts of the system have to be factored in. There is a degree of substitutability within the entire transport sector, which is not clearly defined and does not apply to all mode-to-mode changes. For certain routes between nodes in transport network a form of transport can have a default position, but this may change when external conditions change. This information can be used to identify bottlenecks in the transport system and which preventive measures can be taken to avoid the failure of the transport system as a whole between different nodes in the transport system. For instance, crossing the English Channel is known for ferry and air transport but after the construction of the Tunnel, surface transport has partially gained a substitution position in the United Kingdom as to travelling to France and the rest of continental Europe.

From the outset, it is also evident that not all transport modes, regions and types of transport interact in the same way. In some cases there is no meaningful substitution available, which is a fact that needs to be taken into consideration. For instance, the fact that passenger transport on ships is mainly for leisure travel purposes means that people are less interested in reaching the destination as such but more focused on the travel experience. Nevertheless, when encountered with extreme weather or natural disaster the safety of passengers becomes an important issue, such as in any other case of passenger transport in any other mode.

The project-specific objectives of MOWE-IT were the following and they were studied accordingly step by-step:

1. Addressing the cross-modal features of European transport system, key determinants of travel choice and distance-destination relationships between transport modes across Europe (WP2)
2. Mode-by-mode (road, rail, aviation and waterborne transport, WP3-6) review of impacts and mitigation strategies of natural disasters and extreme weather events currently available for industry, operators and regulators.
3. Preparation of short-terms options to dealing with induced disruptions, including the availability of alternative transport options in the form of less affected transport mode options (WP7)
4. Providing policy recommendations for longer term solutions to reduce disruption to the European transport system caused by extreme weather phenomena (WP8).
5. Involving stakeholders, including the transport industry, and authorities from a variety of fields (border and customs control,
emergency services, health sector etc.) in order to create an arena in which the adaptation process can be discussed in a cross-modal perspective and a wide geographical scope (WP9).

The work packages had an interaction mechanism, which was based on the sequencing of the activities between work package 2 and work packages 3 to 6 and further between work packages 2 to 6 and work packages 7 to 8. By starting the work package 2 before the mode-specific work packages 3 to 6 the structure ensures that the cross-modal considerations will be embedded into mode-specific reviews. As the work package 2 continued after the work packages 3 to 6 were concluded the feedback to cross-modal considerations was ensured. The start of work packages 7 and 8 overlapped with the completion of work packages 2 to 6, again ensuring that the conclusions were driven from the reviews conducted. Key participants of work packages 2 to 6 had also membership in work packages 7 to 8, again ensuring that the findings were translated into roadmaps and policy guidelines.

Project Results:
Cross-modality work package results (WP2):

Overview of the work

Keeping in mind that MOWE-IT is a CSA-SA type of project, it is not possible to carry out research activities within the project scope. As there is no real database available on cross-modality opportunities at the European level, it was decided that a database and tool to visualize it would be developed within the project to showcase the alternatives for mobility of people and goods in the case of disruptions.

Starting point was to select a network of major airports in Europe to prepare a core network of connections for analyses. Passenger and trade volumes data were starting point of analyses. Of latter we have taken notice of poor data availability of goods transported in terms of content, value and destinations within Europe.

The work carried out in work package 2 was documented in D2 of the project. Based on the airport passenger flows data, combined with cost and time data of travel on alternative transport modes, a comprehensive mapping of travel alternatives in Europe was completed. Based on these results, the interactive tool to map out developments was created. The tool utilises future weather scenarios and helps to predict alternative travel scenarios for present and future predicted weather conditions.

CERTH-HIT utilised the collected data to develop a framework, which would allow modelling of the cross-modal opportunities. This framework very clearly explains the travel choice patterns, when the parameters of travel are clear. The framework was adjusted to also analyse the future opportunities, and with more data added to the framework it can be even developed further. Figure X below illustrates the framework of analyses.

The interactive tool is available at the MOWE-IT website and will be also linked to have access through Commission's climate change website for use beyond MOWE-IT project timeline. In the future, it is possible to update the tool with more locations, more accurate weather data and new future weather conditions data. In addition, cost and time factors may also change, but can be updated as well. The principles of the tool are presented in greater detail in the following section.

Interactive tool

USER INTERFACE FUNCTIONALITY

The client-side UI is divided into four modes: Climatic Scenarios, Comparison of Climatic Scenarios, Impact on Passenger Flows, Info.

Climatic Scenarios

The UI of Climatic Scenarios mode consists of a map, timeline for different temporal periods and a search field for locations. The map shows a small dot for each of the 134 European locations that have existing weather phenomena data. For displaying the data, the user can click a location dot or type the desired location into the search field, and choose one of the three temporal periods from the timeline. This action leads to data to be visualized with a tree structure on top of selected the location. Figure 1 depicts an illustration of the tree structure.

The tree structure consists of location name and the data for each weather phenomenon. Each weather phenomenon has its own icon which acts as an on-off switch for showing a tree branch containing the corresponding weather phenomenon data. Thus, the user can decide which phenomena data are visible. If the temporal period is changed, the shown data are changed automatically in order to correspond the selected period.

Comparison of Climatic Scenarios
This mode is similar to the Climatic Scenarios since the source of data is the same and the same tree visualization is used. The main difference is that the user can select two different locations and see the visualizations of the corresponding data on top of each other on the right side of the view, as can be seen in Figure 2.

Impact on Passenger Flows
In the case of Impact on Passenger Flows the UI consists of a map, search fields for locations, a list of extreme weather events added by the user and a form which is used for adding the new events. The map shows a small dot for each location belonging to a group of 14 pre-selected European locations. Before the user can see any visualizations he is required to assign at least one weather event to some location and define type, transport mode, occurrence probability, operation reduction and duration for it. The user can, in addition to adding new events, modify and remove existing events.

The location, to which the event is assigned to, will be the origin of the connection. At this point, the user is able to click one of the other 13 locations (or choose from a drop-down list) which will then be assigned as the destination for the connection. The passenger flow data is then visualized using two curved lines connecting the two locations (Figure 3). One line presents the current situation ignoring the added weather events and the other shows the future scenario which is calculated using the added events. Both lines are composed of three parts each representing one of the three transport modes (air, rail and road). A line is divided amongst these three modes by their percentage of the total number of trips combined from all three modes. The user is able to reverse the direction of the connection by clicking an arrow button in the between the two lines.

Info
The info mode contains a description of the visualization tool, including backgrounds, purpose and usage guide, as well as a button for downloading the all the data used by the tool as an Excel file.

Road transport work package results (WP3):
Work Package 3 of the MOWE-IT project was dedicated to road transport. More precisely the WP looked at the vulnerabilities and to resilience-related issues of road operations from the viewpoint of road users. These include individual persons travelling by foot, bike, car or coach, as well as freight forwarders using road haulage services. Road infrastructure damages and adaptation options for road infrastructure owners and managers are more indirectly included as of course road damages and road works impact system availability for the users. Within this framework the objectives of WP3 can be formulated as follows:

• Describe in detail the vulnerability to weather extremes in road operations, private travel and commercial passenger and freight services across Europe
• For each actor group identify reaction patterns in emergency situations and work out areas of potential improvement (including intermodal coordination).
• Identify information and technology availability and development needs, including targeted weather data provision, for more resilient systems for all road transport actors.

To meet these objectives the WP has been broken down into 6 tasks, dealing with the overall methodology (Task 3.1) reviews and case studies for the three main types of actors (Tasks 3.2: road authorities and weather services, 3.3: passengers, 3.4: freight forwarders) and the WP's outputs (Tasks 3.5: RTD roadmap, 3.6: Guidebook). The crosswise relations of these tasks to each other are best described by the following flow chart:

Work package 3 was lead by Fraunhofer ISI and supported by FMI, Vaisala, KIT, ISIS, CERTH-HIT and VTT. Major highlights of the work packages were:

• Organisation of a workshop on road transport resilience at September 22nd in Brussels with presence of major European institutions and presentation of relevant European and international projects.
• Presentation of the Road Transport Guidebook at TRB (Washington D.C USA, January 2014), RMIT University (Melbourne, Australia, April 2014) and TRA (Paris, April 2014).

The following sections will briefly provide the main findings of the six tasks.

Task 3.1: Assessment guide and the value of information
A review of current literature and a look at current conferences show that there is numerous information available on the impact of natural hazards on settlements, economy and transport. Also we find a great number of studies on adaptation options. With a few examples, however, these incident reports and scientific analyses are readily usable for decision makers in public administrations and road authorities.
By a meta analysis of different cases we find the general story line that preparedness – usually based on exploiting previous experiences – helps to reduce damages and entailed economic costs. Great examples in this respect are the series of storm surges in the US (Katrina, Rita, Irene and Sandy) or the two one-in-100-years floods in Germany and bordering countries (1999, 2002 and 2013). The international Road Association PIARC has recognized the value of this information and published a number of guidelines for road users. Also the World Bank and the European Environment Agency (EEA) started endeavours to assess and share such information. Recognising this, but also acknowledging the lag of systematic collection and spreading of experiences on events, good or bad preparedness and other lessons, Task 3.1 has developed a reporting form for case studies for road transport. This was used by later tasks to report on selected cases. The respective case study reports are made available on the MOWE-IT website. However, we have to place the disclaimer as MOWE-IT as a CSA project is not allowed to conduct original research the templates have been filled with information available through literature reviews only. Later research may extend them by interviews, data analyses or other original inputs. The reporting form was structured as follows:

- General description: weather conditions. location & time, general impacts
- Specific impacts on roads: infrastructure failures, operations, specifics on WP2 corridors, duration and recovery times, financial impacts.
- Response: Actors, preparations in advance, emergency response, effectiveness, institutional learning, repair and adaptation procedures, road industry issues,

The related case studies will be addressed in the specific sections below.

Task 3.2: Road authorities and weather service providers

The potential impact of extreme weather on road transport depends also on the awareness of the road stakeholders and authorities, i.e. to the level of risk management applied. This calls for a sufficient weather observation network and skillful numerical weather prediction models. Good co-operation and coordination between all involved authorities, as well as effective communication and exchange of information are needed to mitigate the impacts of harmful weather. Of importance is also the clear definition of responsibilities of all parties in emergency situations in order to achieve coordination.

Short and long term impacts of climate change may necessitate more frequent maintenance and reconstruction. Recent research and support activities developed a number of risk assessment tools which are available to road authorities and which give advice on the usefulness and costs of various measures to improve resilience. These are the RIMAROCC methodology developed by the ERA-NET ROAD programme and the CAPTA model prepared by the U.S. Transportation Research Board. Good national examples can further be found in Switzerland, Finland and the UK.

Proper risk mapping is inevitable in particular for flood risks, but often lacking. Given the demographic development in Europe, which results in stagnating or even declining transport demand volumes, the maintenance of existing roads should gain more attention. In the past, the decisions about necessary actions (e.g. on gritting and salting) were the responsibility of the road maintenance personnel. In addition: to ensure an efficient and effective road management, the establishment of a common crisis management (including businesses, public and private road users) and the introduction of contingency plans are necessary.

Task 3.2 has conducted the following case studies:

- Infrastructure impacts of UK floods 2007
- RWIS in the 21st century
- Car crashes in Helsinki 2012

Task 3.3: Road passenger transport

Different countries have developed various good practices and methods that aim towards improving the service provided to road users, and some countries even monitor citizens’ satisfaction with the information provision by respective surveys. A survey among 24 regions in 16 European and 5 world countries by PIARC reveals that Internet. radio, SMS-services and variable (road side) message signs (VMS) constitute the most frequently used sources of pre- and on-trip information by road users.

Of increasing importance is the information exchanged between vehicles, road operators and drivers. Car-to-car or car-to-Infrastructure communication systems are not anymore pure research subjects, but are installed in vehicles and roads today linking car manufacturing closer to road operators and weather data providers. But there still are serious concerns on the following or warnings and traffic advices by actual users. Here behavioural research and personal information channels are needed.

Concerning vulnerabilities statistics mainly from the US find that 5% to 10% of traffic incidents and around 10% of congestion is inflicted by harsh weather conditions. In both cases heavy rain and wet pavement are the main sources, which can be explained by two facts: rain occurs way more frequent than other extremes and people get more cautious under winter and storm conditions than with rain. Comprehensive European data is missing.

Task 3.3 has conducted the following case studies:

- Winter cycling in Oulu, northern Finland.
- Short- and long-term emergency management operations for EWE/NH impacted passenger transport during the 2007 wildfires in
Peloponnesus.

- Organisation of emergency bus services in Munich.

Task 3.4: Freight transport and logistics
The adaptation of logistics and freight transport to climate change, also referred to as “adaptive logistics”, considers how such systems can better respond to the impacts of climate change. Coping with the impacts of extreme weather events for several modes simultaneously is one of the main challenges to be addressed for the freight and logistics sector.

The impacts of weather extremes on freight transport and logistics are poorly documented in the public domain due to commercial privacy reasons of transport and industry sectors. They regard service disruption, economic losses, trip re-scheduling and re-routing and delays in deliveries. Among other extreme weather events, floods and severe rainfalls can lead to accidents, transport infrastructure disruptions and closures. The economic impacts on the overall industry can be in the order of millions of euros.

Trucks are generally more weather-resilient than cars. Weather does not play a major role for truck safety as vehicles are heavy; speeds are lower than in car travel and drivers are trained. Translating general US delay statistics to the milder conditions in Europe and the more stable driving cycles in road haulage we may estimate weather share at truck delays below 5%. These figures, however, do not contain trip cancellations or shifts in time.

Task 3.4 has conducted the following case studies:
- Impacts of flood events on the Greek road logistics sector.
- Flood impacts on road logistics in Germany, Austria and the Czech Republic, Summer 2013.
- UK construction sector and extreme weather events.
- Transportation sector’s response to and recovery from the hurricane Katrina and the effect these disruptions had on the national-level movement of freight.
- Economic impact of the storm-related closures of several highway segments in the winter 2012 on road logistics.

Task 3.5: RTD roadmap
The road transport adaptation roadmap was built on the basis of literature statements, expert interviews and the road transport workshop conducted in Brussels, September 22nd 2014 in the ECTRI offices. Statements of road operators, PT, coach and logistics operators associations, meteorologists and researchers the following set of recommendations was developed:

Understanding user behaviour
- Explore user needs for personalised emergency warnings and travel recommendations
- Rebound effects of safety technologies: explore the impact of increased passive and active safety technologies on driving habits in critical situations and on drivers’ readiness to prepare for adverse weather conditions.

Technology development
- Improve the liability of driver assistance systems with regards to fatigue control, the recognition of non-motorised traffic participants in the blind angle at low speeds or skid control on slippery (icy or wet) pavements.
- Develop intelligent feedback systems in vehicles keeping the users’ attention even despite possible frequent false alarms, etc.

Economics and incentives
- Develop sustainable business models for the provision of high quality, multi-modal and personalised emergency information systems.
- Work out guidelines for benefit cost assessment of increased reliability of transport undertakings, for the company itself and for the society as a basis for defining appropriate public support schemes.

These recommendations were taken up by MOWE-IT Deliverable 8.1 which formulated a RTD roadmap for all modes and in particular for intermodal issues.

Task 3.6: Road transport guidebook
The guidebook on road transport constitutes the main output of WP3. It is mainly organised by actors to be addressed (weather services, road operators, passengers, freight forwarders and RTD institutions). Besides describing the main vulnerabilities and the respective state-of-the-art technologies procedures for their mitigation it presents a set of detailed recommendations for more resilience in road transport.

As all other project material and together with the 11 case studies elaborated in the project, the Guidebook is available via the MOWE-IT website.

Key findings of work package 3 (road transport)
Organisational and decision making structures: Long-term, strategic measures on policy level, issues on legislation, regulations, and standardisation, high level collaboration, roles and responsibilities for formulation of policies and strategies.

Establish networks of urban, regional and national stakeholders: transport companies, authorities and users. These shall enable mutual support in case of an emergency and the exchange of experiences.

Conduct public campaigns for awareness raising on local hazard situation to the general public. The aim of such campaigns should be to raise awareness for good technical preparedness of vehicles and for higher levels of pre-trip information.

Set and implement international standards for weather and emergency information in order to support cross border emergency missions.

Explore options to co-operate with competitors under adverse conditions, including the formulation of cost and burden sharing for a fair allocation of risks and benefits.

Support road authorities and transport service providers by issuing guidelines, leaflets and other education and information material on maintenance, good preparedness, contingency planning and procedures in emergency cases. PIARC and UKRLG guidelines provide excellent starting points, but need to be translated to national and regional contexts.

Pave the legal and knowledge grounds for innovative procurement and supply models for road authorities. These could be on de-icing salt, sand bags, snow ploughing equipment, etc. Insurance solutions could be an option.

Consult and co-ordinate with other highway authorities, subcontractors, suppliers and key stakeholders to adjust strategies, e.g. when defining strategic maintenance networks or materials and equipment supply.

Technical options and possibilities to reduce risk:

Operational level actions on physical infrastructure (repair, maintenance, installations) – before, during, after a hazardous weather event.

Provide sufficient shelter for non-motorised transport (bike parking, waiting facilities) according to protect from most relevant local hazards.

Regularly clear cycle lanes and sidewalks in winter- or clearly communicate alternative strategies.

Prepare for sufficient salt stocks and road clearing equipment availability before and during winter or storm seasons. UK winter experience e.g. recommends 12 days salt stocks. Innovative and / or collaborative procurement models could be interesting.

Procedural and operational options to mitigate the risk:

Managerial procedures, action plans, decision-making and responsibility assignments, adaptation of working modes, collaborative actions between stakeholders to mitigate risk – before, during, after a hazardous weather event.

Evaluate the possibility of compulsory safe driving training for all drivers. Furthermore support the training of drivers and other staff in the transport sector. While the trainings and certificates could be issued by private players or associations, e.g. automobile clubs, the contents should be defined by public authorities to ensure regional consistency and completeness.

Develop risk maps for the local area and derive from that appropriate action plans according to the risk mapping. This should ideally be supported by national or European risk mapping activities.

Establish priority plans for road clearance with regard to maintaining access to emergency stations, hospitals and for public transport within and beyond city boundaries.

Organise the supply of trapped drivers / passengers with the help of volunteers and aid organisations. To be prepared, collaborative contingency plans and contracts should be established beforehand.

Keep track of chain reactions of weather extremes in particular in agglomeration areas.

The freight marketplace is characterised by the presence of several companies, often SMEs with self-employed owners. The success of warning alerts and communications policies from public authorities preventing extreme weather episodes, rely on timely communication and coordination plans involving stakeholders and freight operator associations.

Freight transport are linked to a complex infrastructure-network, and to multimodal links over vast territories. The effectiveness of policies depend on the coordination of emergency plans amongst transport modes (infrastructure managers) and networks, e.g. national, regional and local roads, ports and the rail network.

In hazard prone regions establish procedures to adapt time tables and service intensities under inclement weather conditions.

Review maintenance contracts and procedures to be flexible and effective even under rapidly changing weather conditions. Regularly clearing of cycle lanes and sidewalks in winter- or communication of alternative strategies.

Implement appropriate risk management procedures in order to be prepared to adverse conditions. This includes risk mapping, staff training, communication structures and the identification of actions.

Define priority routes for road clearance in case of large scale impacts, such as icing, snowfall, flooding, landslides or storms. These should include all strategic roads and access to key facilities. Strategic routes should be selected on seasonal rather than average annual traffic volumes.

Information flow, ICT support (e.g. monitoring by satellites) and passenger services: Development & implementation of ICT.
technologies and services for passenger and freight transport
Use different channel and information supplies to regularly check for emergency warnings and recommendations. Select and adapt the source best suited to your personal habit and mobility style. However, do not over-emphasise their precision
In public transport provide reliable, instant and - if feasible – personalised information on duration of the incident and on travel options
At company level, in particular with SMEs, who lack of business continuity and financial means of bigger companies, public policies reducing underinsurance and providing services and information (via internet and social network) may improve the resilience of company supply chain to extreme weather events
Explore user needs for personalised emergency warnings and travel recommendations
Develop sustainable business models for the provision of high quality, multi-modal and personalised emergency information systems
Develop intelligent feedback systems in vehicles keeping the users’ attention even despite possible frequent false alarms, etc.
Foster the operational-, physical -, technical -, procedural - and institutional integration of weather and traffic control services
Prepare timely and broad communication on disruptions and alternatives with the public, using different communication channels (radio, internet, social networks, etc.)
Improve the liability of driver assistance systems with regards to fatigue control, the recognition of non-motorized traffic participants in the blind angle at low speeds or skid control on slippery (icy or wet) pavements
Standardize weather information and hazard warnings across Europe. These should ease the co-operation of meteorological institutions and support suppliers of trans-European transport services
Rebound effects of safety technologies: explore the impact of increased passive and active safety technologies on driving habits in critical situations and on drivers’ readiness to prepare for adverse weather conditions
Decision and risk models:
Development of risk and decision-making models and impact assessment and evaluation procedures.
Assess the company's risk exposure and establish appropriate adaptation, emergency preparation and emergency response plans.
Inform and train the staff regular basis
Work out guidelines for benefit cost assessment of increased reliability of transport undertakings for the company itself and for society as a basis for defining appropriate public support schemes
Work package results 4 (Rail transport)

Guidebook for Enhancing Resilience of European Rail Transport in Extreme Weather Events
The goal of this work package was to identify existing best practices and to develop methodologies to assist rail operators, infrastructure managers and system users to mitigate the impact of natural disasters and extreme weather phenomena on rail system performance. A large-scale review of case studies of the impact and management of extreme weather events over recent decades in Europe and beyond was conducted. These case studies built on existing examples from the EWENT, WEATHER and FUTURENET projects, but also included numerous novel studies which had not previously been developed. These were divided into three broad categories: heavy rain/flooding, wind, and snow/winter conditions. The case studies used were as follows:

Heavy Rain
• Saxony Flooding 2002
• Alpine flooding 2005
• UK summer flooding 2007
• Intense convective storms UK June 2012

Wind/storm
• Storms Lothar and Martin 1999
• Windstorm Gudrun in Sweden 2007
• Storm Kyrill over Western Europe 2007

Snow/winter conditions
• Heavy winter conditions in Stockholm 2001-2002
• Exceptionally hard winter conditions in Sweden 2009-2010
• Impact of winter conditions on Eurostar services 2009
• Exceptionally hard winter in Southern Finland 2009-2010
• Winter 2009-2010 in Europe

Guidelines and recommendations were derived from the case studies and split into long-term planning and resilience building measures and actions which can be implemented before, during and after a given event. A number of recommendations and guidelines for the reduction of weather impacts on rail operations were synthesised from the experiences reported in the case studies. These included a range of actions such as improving the resilience of physical infrastructure to specific weather conditions, learning from past events and dealing with affected passengers. As well as weather-specific guidelines, a number of broad recommendations that
are applicable to most weather-related events were also formulated. These were divided into the different areas of the railways including vehicles, infrastructure, equipment, operations, information, cooperation, staff and weather forecasts. The output from this sub task included 13 detailed case study reports (including several additional reports that were excluded from later discussion for brevity), three weather-specific documents synthesising the findings and discussion, and a draft summary guidebook.

The MOWE-IT rail workshop was held in Brussels on the 17th of September 2013 and was tasked with synthesising guidelines and recommendations on how extreme weather events can be managed. 17 invited participants took part. These mostly came from large European infrastructure managers and railway companies such as Network Rail, ProRail, SNCF and ÖBB, but also had from weather service providers(UbiMet) and industry bodies (UIC). The participant group was supplemented with members of the MOWE-IT advisory board and project partners. The event focused on several areas, including the management of different types of weather events and the higher-level governance and structures that must be in place to implement successful strategies during extreme events.

Participants were sent draft guidelines and recommendations that had been drawn up by the MOWE-IT Work Package 4 team as well as links to the three weather-specific documents. The individual case study reports were also available on the day for discussion in the break-out groups.

During the event discussion focused on the following areas:

- The feasibility and effectiveness of the proposed measures.
- How overarching strategies can be put in place to implement the measures during an event.
- How skills and expertise of dealing with weather events can be captured and retained in an organisation.

The recommendations were broadly supported by the participants, but with a number of important modifications and additions that should enhance their applicability to the industry. The weather-specific recommendations were given useful contextual information based on the experiences of the participants, uncovering additional advice not contained in the case studies. Much of this advice centred on cutting-edge hazard modelling and improved local-scale weather/hazard forecasting so that preventative action and better prioritisation of resources can be made in the build-up to an event. In the afternoon session a wide-ranging discussion was made on the higher-level management and governance needed to ensure that the individual measures can be implemented in a holistic manner during an event. Discussion was also made of how important experiences and tacit knowledge gained during an event can be captured and retained within organisations and perhaps shared at an international level. Funding options and possibilities of future collaborations at a European level were also discussed.

The input from the workshop was fed into the final version of the guidebook. The document addresses governments and the management and board of railway companies (infrastructure and transportation). It does not directly address working and operative staff of railways. The authors recognize that these individuals are doing a good job in case of extreme weather conditions and do their best on the basis of information and equipment they have in case of hazards. Looking at the recommendations in this guidebook three aspects have to be mentioned:

- Most of them are very well known by experienced people in railroading, especially operative staff on the track, the control centres and the work-shops.
- Gaps, short-comings and difficulties are often a result of bad preparation, lack of buffers, resources for preventive maintenance and the number of skilled staff among others. These deficiencies result from political and/or management decisions.
- Without skilled and motivated staff we still have in railway companies, impacts of hazards can become even worse, staff-balance short comings mentioned above and in the guidebook. Unfortunately the number and motivation of local working and operative staff is shrinking in most railway companies. Coming from overstuffed public enterprises we now recognize lacks of staff in some railway systems.

The recommendations and findings are results of the case studies and the experiences in extreme weather conditions the authors identified from desk research or having been involved is as railway passengers. They should be taken into account for strategic decisions and adopting the rail system for extreme weather events. Indeed the recommendations are not rocket science. Some of them have already been established previously but have been forgotten, neglected or disestablished in the only economical design of railways.

Key findings of work package 4 (rail transport)

Organisational and decision making structures: Long-term, strategic measures on policy level, issues on legislation, regulations, and standardisation, high level collaboration, roles and responsibilities for formulation of policies and strategies.

raise awareness of adaptation to climate change.

establish greater regional and international exchange of good practice.

Technical options and possibilities to reduce risk:

Operational level actions on physical infrastructure (repair, maintenance, installations) – before, during, after a hazardous weather event

Long term, advance preparation:
install local weather forecasting systems where needed
assess weather-related infrastructure problems identified during previous events
assess vulnerabilities of vehicles to specific weather types observed during previous events; adapt and enhance resilience
improve, maintain and monitor infrastructure (e.g. drainage network, areas close to tracks and catenaries clear of vegetation and
dangerous objects)

Key findings of work package 5 (Aviation)
Guidebook for Enhancing Resilience of European Aviation in Extreme Weather Events

Various adverse weather events occurring over the European continent have a potential to impact the European aviation system. Due to
locally varying conditions these events are more frequent in some regions than in others. However, their potential to impact the aviation
system depends also on the awareness of the aviation authorities. Due to a changing climate it has to be expected that the patterns of
adverse weather change to some degree.

The aviation guidebook addresses the most important types of adverse weather for aviation including information on their
geographical and seasonal relevance; the expected changes until the 2050s (and 2020s, if significantly different); typical duration and
warning times and their impact on aviation transportation networks in more detail. It has to be noted that regional climate models
cannot reproduce all types of weather events with the same accuracy and that results partially disagree between the models.

1.2 Aviation Weather Influence Assessment
As documented by the monthly reports of the European Organisation for the Safety of Air Navigation EUROCONTROL, weather is
among the main contributors for delay depending on the time of the year. The European Aviation Safety Agency (EASA) registers
weather as contributing but not as causal factor for incidents or accidents. The reason for these facts can be explained by the high
safety standards in aviation, which come immediately into action when weather events with hazard potential appear. As a safety
response to weather events changes in operational procedures are initiated, which finally lead to delays or even cancellations.

To assess the impact of adverse weather events on the European aviation network, important parameters are – besides duration, type,
and intensity of weather events – related to the affected sectors and airports. Bottlenecks of the recent ATM system are especially
congested airports operating on or beyond their airside capacity limit. This can be seen at the international and European hub airports
rather than at secondary ones. Even minor weather events can lead to disruptions in the flight plan. Adverse weather events at these
congested airports will result in limitations of the airside capacity, delays, or re-routings due to increased separation minima and
reduced runway conditions. In this context, the SESAR (Single European Sky ATM Research) program of the European Commission
aims to provide better technology and harmonise procedures in order to meet future capacity and air safety needs. Although increasing
resilience was not the main idea of SESAR, some of the developed technologies and procedures intend to keep capacity as high as
possible in usually disruptive conditions.

From our point of view, special attention has to be given to adverse weather events that threaten the European aviation system such as
long-lasting snow fall, freezing rain, or thunderstorms. All airports, independent of their size, can be hit by these events that may both
disrupt connections to other modes of transport and lead to a partial or complete shutdown of an airport. An important factor is the
areal extent of adverse weather events. A first step towards higher resilience of airports and the air traffic network is the understanding
of the particular influence of weather events and the propagation of disruptions within the air traffic network. Figure 1 provides a short
overview of the most important weather types and their impact on aviation. These impacts lead to different operational reaction
patterns as illustrated in Figure 2. The reaction patterns are usually local measures that often have an impact on the aviation network.

Figure 1: Weather events and impact on aviation

Large-scale weather related disruptions are of great importance for the whole aviation industry as the problems occurring at hub
airports may even have an impact on airports that have not been directly affected by these weather events so far. The number and size
(in terms of passengers as well as physical aircraft size) of redirected aircraft will have an impact on alternate airports. Especially the
airline network over central Europe with its high density of important international hub airports seems to be prone to large-scale weather
related events in particular.
Figure 2: Impact of weather events and operational reaction patterns

Each airport has its own experience in applying suitable response measures. By intensifying the exchange among airports and stakeholders best practices can be shared and preparation for events that might become more frequent due to climate change could be fostered.

2. SUMMARY OF RECOMMENDATIONS
This section summarises actions described in the aviation guidebook that we recommend to take into account for further developments. Some more general aspects are extended by examples in order to improve understanding of these ideas.

2.1 Recommendations for European and national policy

- Research efforts related to the analysis of disruptive effects to the aviation sector shall be encouraged. To allow an estimation of the influence of weather related disruptions, the network influence and propagation of delays have to be understood.
- The development of a measurement system to assess and compare the vulnerability of airports and airspace areas would allow the establishment of priorities for research activities. New performance measures may be developed that are able to assess performance for future scenarios under changing climatic conditions.
- More transparency in the comparison of the impacts of disruptive events shall be fostered, thereby addressing imprecision in the definition and assignment of codes and terms as e.g. when to assign which IATA delay code or the definition of consistent statistical evaluation procedures. The aim is to allow a correlation of disruptions to the original cause. Precise definitions and consistent recording of influences is the necessary basis for comparative analysis.

2.2 Recommendations for the aviation sector

- More passenger oriented approaches shall be fostered, as e.g. the use of customer profiles to provide customer-specific alternative travel solutions in case of disruptions.
- A closer cooperation among stakeholders (meteorological service providers, airlines, airports, and air navigation service providers) helps to generate a common problem understanding. Documenting measures and impacts examined in such cooperation may help other stakeholder groups to identify and learn from best practices for disruptive events. Such best practice guidebooks may especially help aviation stakeholders that will be affected in future due to climate change.
- Climate change aspects shall be taken into account as one future aspect in ATM Master Plans. Besides the direct effects of changing climate addressed in the guidebook, geographical and seasonal demand redistributions should be taken into account for the longer term. Robustness and constraints of constructions and pavements as well as technical infrastructure (e.g. air conditioning of buildings) should be analysed with respect to temperature and precipitation changes.

2.3 Recommendations for research and technical development

- Terms and definitions and their use shall be standardised on an international level in order to facilitate comparisons of impacts of disruptive events and enhance a common problem understanding.
- The activities to improve local weather and disruption forecasts shall be continued. Of special importance is the forecast of thunderstorms, snow, ice and icing, strong winds and wind shears as well as conditions of low visibility or low ceiling on an airport-specific basis. Forecasts with improved geographical and timely precision may help to reduce the disruptive impact.
- The inter-airline and intermodal cooperation shall be enhanced, e.g. through the generation of a new ticket category allowing intermodal flexibility (feasibility of shifting from one mode of transport to another one with one ticket, multimodal ticket use).
- Passenger and weather information services shall be developed to bring passengers into a more active role by enabling them to choose the alternative route and transport mode, respectively, which suits them best in case of disruptions.
- Possibilities for information exchange among customers (esp. passengers) and travel providers (airlines, travel agencies) in order to use customised travel advices shall be assessed.
- It shall be assessed if and how shifts in traffic flows relocate disruptive problems or even may generate new disruptions, e.g. a measure similar to a Level of Service may be developed to denote areas affected by traffic flows and switches of traffic flows, respectively.

Key findings of work package 5 (aviation)
Organisational and decision making structures: Long-term, strategic measures on policy level, issues on legislation, regulations, and standardisation, high level collaboration, roles and responsibilities for formulation of policies and strategies.
Consider climate change aspects in the ATM airport master plan.

Technical options and possibilities to reduce risk:
- Operational level actions on physical infrastructure (repair, maintenance, installations) – before, during, after a hazardous weather event
- Improve capacity of restricting equipment (e.g. snow removal equipment, air-conditioning).
- Install common control and steering centres including intermodal services.
- Implement the in SESAR developed technologies and procedures aiming to optimise capacity in disruptive conditions.

Procedural and operational options to mitigate the risk:
- Managerial procedures, action plans, decision-making and responsibility assignments, adaptation of working modes, collaborative actions between stakeholders to mitigate risk – before, during, after a hazardous weather event
- Define responsibility for travel rearrangements and additional costs for journeys in case of multi modal traffic chains.
- Information flow, ICT support (e.g. monitoring by satellites) and passenger services: Development & implementation of ICT technologies and services for passengers
- Provide customized travel advices (smartphone apps, websites).
- Develop passenger and weather information services offering passengers a more active role by enabling transport mode shifting.

Decision and risk models:
- Development of risk and decision-making models and impact assessment and evaluation procedures.
- Develop a measurement system to assess and compare the vulnerability of airports and airspace.
- Boost transparency in the comparison of the impacts of disruptive events (consistent statistical evaluation procedures).
- Continue improvements of local weather and disruptions forecast (forecasts with improved geographical and timely precision may help to reduce the disruptive impact).

Key findings of work package 6 (maritime and inland waterways)

Guidebook for Enhancing Resilience of European Maritime Transport in Extreme Weather Events – Summary

Maritime key conclusions:
- Organisational and decision making structures: Long-term, strategic measures on policy level, issues on legislation, regulations, and standardisation, high level collaboration, roles and responsibilities for formulation of policies and strategies.
- Collaboration between weather services, oceanographic institutes and other shareholders could provide much needed experience and pooling of resources.
- IMO's bureaucratic decision-making mechanisms require improvements. Slow response to actions needed causes delays and subsequent economic losses.
- Standardisation and system requirements to help quicker adoption of technologies in ports by authorities and to create a way to enforce the implementation.

Technical options and possibilities to reduce risk:
- Operational level actions on physical infrastructure (repair, maintenance, installations) – before, during, after a hazardous weather event
- Identifying the potential safety issues in ports and working with stakeholders on how to overcome them.
- Some national weather related safety instructions and commands concern also the operations of ports. As these instructions often come with a cost, it is necessary to consider who should pay for the investments required. Models of managing the safety investments need to be clarified in various port ownership situations.
- Information flow, ICT support (e.g. monitoring by satellites) and passenger services: Development & implementation of ICT technologies and services for passenger and freight transport.
- There is a gap in both effectiveness and efficiency in new technologies, sensors, weather forecasting etc.

Decision and risk models:
- Development of risk and decision-making models and impact assessment and evaluation procedures.
- Improving the quality and reliability of wind forecasts by using WRF (Limited Area Model) down to a 2 km resolution
- Comparison of weather forecast model outputs against reliable observed data for the forecast location is needed. With empirical
comparison available forecasts become more accurate, more effective. Decision makers increase in confidence and make more effective decisions, increasing the efficiency and safety of operations.

Inland waterways (WP6)
Guidebook for Enhancing Resilience of European Inland Waterway Transport in Extreme Weather Events – Summary
Inland waterway transport (IWT) is a cost-efficient and environment-friendly mode of transport. It is associated with a high degree of reliability and safety, as well as the lowest noise emissions being reflected in the lowest external costs related to one ton (t) of cargo transported over one kilometre (km), compared with other modes of transport.

Extreme weather events relevant to inland waterway transport are low-water events (drought), high water events (floods) and ice occurrence. Of less importance are wind gusts and reduced visibility. There is no convincing evidence that low-water events will become significantly severer on the Rhine as well as the Upper Danube in the near future. On the Lower Danube some impact of drought in association with increased summer heat might appear, demanding however dedicated research. Related to high-water events no reliable statement with respect to increase of discharge and frequency of occurrence can be given. However, consideration of floods on inland waterways will remain important also in the future due to reasons related to flood protection.

In the Rhine-Main-Danube corridor no decrease in the performance of inland waterway transport due to extreme weather events is expected until 2050. As a consequence, inland waterway transport is expected to stay a reliable and cost-effective transport mode. For the more distant future (2071-2100), the costs of inland waterway transport are projected to increase more significantly in Danube and Rhine waterways due to adverse impacts of climate change. Nevertheless, the implementation of short-term measures presented in the guidebook will improve the navigation conditions already today. The inland waterway transport sector will benefit from these measures immediately, not only in an uncertain future. Long-term climate change adaption strategies and related measures shall become part of an overall long-term European inland navigation policy.

The adaptation needs in particular refer to the year 2050 and beyond when climate change is projected to change the discharge characteristics of the Rhine-Main-Danube corridor more significantly.

Adaptation Strategies
Using the knowledge gained with respect to changes in hydrology and navigation conditions, the impact of climate change and extreme weather events on inland waterway transport could be evaluated and assessed.

Considering the European transport system, amongst others, the projects ECCONET, EWENT, WEATHER and Knowledge for Climate have recently been carried out. In line with the results of these projects and taking into account outcomes of other activities e.g. the ones of the International Commission for the Protection of the Danube River (ICPDR), MOWE IT proposes the following set of policy actions in order to meet the above mentioned impacts on inland waterway transport:
1. Continuous observation of climate change impacts on IWT and research
2. Development of strategies for adaptation of infrastructure
3. Development of strategies for sustainable waterway planning
4. Development of strategies for enhanced use of Information and Communication Technology (ICT)
5. Support the adaptation and modernization of the IWT fleet
6. Preparation of ports for efficient handling of adapted and modernized vessels
7. Stronger cooperation of waterway administrations and enhanced use of "Smart Waterways"
8. Permanent and pro-active cooperation of river commissions
9. Logistics management

Most Promising Adaptation Strategies
Improving the inland waterway infrastructure by implementation of the respective TEN-T priority projects acknowledged by the European Commission as well as national activities will have a significant positive impact on the reduction of the vulnerability of inland waterway transport to extreme weather events today and in the future. The following two main aspects of inland waterway infrastructure development are to be taken into account:

• Economics of inland navigation, i.e. the connection between the existing waterway infrastructure and the efficiency of transport
• Ecological effects of infrastructure works, i.e. balancing environmental needs and the objectives of inland navigation (integrated planning)

A further measure with high potential comprises the development of customer oriented waterway management. In case of changing water discharge patterns (e.g. altered seasonality of low water periods) the fairway maintenance cycle (surveying, dredging and provision of information) shall be accordingly adapted on the time axis. This includes an optimal timing of the necessary dredging works during the year which takes into account changing temporal distributions of the river's water discharge. Improved utilisation of the fairway can be achieved by provision and usage of up-to-date comprehensive information on the fairway conditions as well as implementation of concepts like "fairway-in-the fairway". For this purpose waterway administrations need to have sufficient and modern surveying equipment (i.e. surveying vessels and software for data processing and analysing). The purchase of such
specialized equipment should be co-funded with the help of European funding schemes (e.g. TEN-T and Structural Funds). The usage of ICT can contribute considerably to managing navigability by providing amongst others up-to-date on-line information on water depths and estimated time of arrival. A major challenge is to link the relevant information and systems, to provide all the parties concerned the necessary information that needs to be shared. Therefore, it is important to either create generally accepted ICT-systems or to make existing systems compatible. This cooperation can be at governmental level, like the development of River Information Services (RIS), but also by the cooperation of private organisations. Smart Waterways would aim at collecting, recording, visualizing and sharing information on water depths. Gains are expected in efficient sailing in times of low water levels from the reporting of up-to-the-minute water depths, water depth forecasts for the coming days and shipments of goods. The navigability monitoring and forecasting system may be based on the echo sounders that are normally mounted on ships plying the river, a data acquisition and processing system, a hydrological low-water forecast model, a morphological bed-topography forecast model and data-assimilation techniques to use measured data for updating real-time navigability forecasts. Therefore the use of these systems asks for strong promotion. Support is needed for the extension of functions and the integration of these systems. A bottleneck to enlarge usage and usability is the lack of budget and/or cooperation among (market) parties.

Organisational and decision making structures: Long-term, strategic measures on policy level, issues on legislation, regulations, and standardisation, high level collaboration, roles and responsibilities for formulation of policies and strategies.

Stronger cooperation of waterway administrations:

development of a state-of-the-art waterway management system as well as on further standardisation and extension of waterway related information.

• Water level information including forecasts
• Actual information on critical / shallow sections
• Accurate information on bridges, ports, locks
• Identification of and access to responsible authorities

Increase of awareness of different stakeholders on climate change impacts on IWT and related industries.

Establishment of a joint “task force” for the purposes of rapid reaction in cases of severe disturbances in navigation caused by hydrological/meteorological phenomena

Communicating the need of secured long-term finance for infrastructure development and maintenance of the entire waterway network.

Operation of an integrated smart network of waterways across Europe.

Supporting the creation of a European river engineering and inland waterways transportation science partnership with the aim of establishing dialogue between the scientific community, the industry and policy makers.

Permanent and pro-active cooperation of river commissions:

Creating a strategy to alleviate the consequences of climate change in river systems

 Enhancing professional qualifications in the sector to ensure availability of skilled personal and attractive job opportunities and to create a business environment of the highest safety standards

Supporting international efforts to reduce adverse air pollution attributable to waterway transportation

Creating a European inland waterway space with minimal administrative barriers and with a maximally harmonised legislative and regulatory framework

Support to the development of a comprehensive inland waterways transport strategy for the next ten years with the overall target to improve the efficiency, competitiveness and environmental performance of inland waterway transportation in Europe.

Support to the implementation of the Joint Statement of Environment & Inland Navigation Development by providing technical assistance

Issuing guidelines on the application of environmental legislation relevant to ports and waterways

Encouraging the formation of multi-sector clusters and promoting technological innovation for fleet modernisation, fleet operation, port & terminal infrastructure

Support the adaptation and modernization of the IWT fleet:

Adequate legislation and creation of an efficient and harmonized regulatory framework

State-aid schemes which stimulate the transition to innovative, adapted, efficient and more environmentally friendly vessels.

Technical options and possibilities to reduce risk:

Operational level actions on physical infrastructure (repair, maintenance, installations) – before, during, after a hazardous weather event

Preparation of ports for efficient handling of adapted/ modernized vessels:

Provision of adequate berths, anchorages and shore equipment to handle larger number of vessels due to increased convoy size.

Infrastructure adjustments/provision of vertical quays in order to accommodate transhipment even under extreme low water conditions.
Improved fairway maintenance in port areas (e.g. optimized dredging).
Upgrade of transhipment facilities enabling transhipment under extreme low water conditions and providing cost-effective throughput capacity for alternating volumes.
Increase storage capacities for increased seasonal logistics buffers and additional value added services for logistics chain modifications.
Provision of adequate fendering systems (for vessels of higher damage sensitive lightweight structures).
Procedural and operational options to mitigate the risk:
Managerial procedures, action plans, decision-making and responsibility assignments, adaptation of working modes, collaborative actions between stakeholders to mitigate risk – before, during, after a hazardous weather event
Adaptation of working hours of ports & terminals for handling vessels adapted for continuous operations.
An improved infrastructure management by waterway administrations
- short-term adaptation measures addressing continuous waterway maintenance activities and strategy.
- continuous and differentiated monitoring and analysis of the development of the river's water discharge regime.
- structural modifications of river engineering works as an adequate response to more severe climatic changes.
Development of adaptation measures for infrastructure planning:
Emphasis on economics of inland navigation, i.e. the connection between the existing waterway infrastructure and the efficiency of transport
Consideration of ecological effects of infrastructure works, i.e. balancing environmental needs and the objectives of inland navigation (integrated planning).
- Identification of integrated project objectives incorporating inland navigation aims, environmental needs and the objectives of other uses of the river reach such as nature protection, flood management and fisheries
- Integration of relevant stakeholders in the initial scoping phase of a project
- Implementation of an integrated planning process to translate inland navigation and environmental objectives into concrete project measures thereby creating win-win results
- Conduct of comprehensive environmental monitoring prior, during and after project works, thereby enabling an adaptive implementation of the project when necessary
Information flow, ICT support (e.g. monitoring by satellites) and passenger services: Development & implementation of ICT technologies and services for passenger and freight transport.
Enhanced use of Information and Communication Technology "smart waterways": create generally accepted ICT-systems or to make existing systems compatible. collect, record, visualize and share information on water depths.
support the extension of functions and the integration of the River Information Services (RIS) systems (current lack of budget and/or cooperation among (market) parties)
Decision and risk models:
Development of risk and decision-making models and impact assessment and evaluation procedures.
Development of adaptation measures for infrastructure maintenance:
Development of innovative methods for the improvement of river monitoring (shear stress, sediment transport, morphodynamics etc.).
Development and programming of numerical models (3D hydrodynamics, sediment transport and habitat modelling).
Development and optimisation of river engineering works in order to improve navigable conditions in line with the minimisation of river bed degradation, the optimisation of flood protection and maximisation of improvements in environmental conditions.
Improved infrastructure management by waterway administrations.
Improved hydrological predictions
Logistic management:
Development of risk strategies

Potential Impact:
Summary of work package 7 results (short-term adaptation)

WP7 of the MOWE-IT project had as a first and foremost objective to formulate roadmaps and guidelines of actions, measures, strategies and policies for the reduction of the vulnerability of the European Transport System in the short future (up to 2020). In an effort to achieve this, several side activities were conducted, each one contributing to the final output, as laid out in Figure 1.
At first, results of previously concluded WPs were brought together and analyzed under Task 7.1 aiming at the identification of major passenger and freight flows in each examined transport mode (road, rail, air, maritime and inland waterway transport). In addition, current network characteristics for all modes were mapped at European level and gathered data information were correlated in order to identify the substitutability opportunities between modes. For the latter, cost (in €) and time (in hours) characteristics of trips between 14 major European hubs were combined in a generalized cost function, whose depiction revealed the cross-modal possibilities of substitution. Figure 2 presents an indicative output of this process.

Figure 2: Substitutability opportunities

At the same time, a Transport Cross Modality Forum was set up, in an effort to bring all involved parties and stakeholders who are capable of promoting international cooperation and of alleviating procedural and legislative barriers for the promotion of transport resilience against climate change. Moreover, a questionnaire survey addressed to transport-related stakeholders was conducted, in order to identify the legislative and organizational barriers, the opportunities for cooperation and the technical options for the promotion of transport cross-modality and networks’ resilience in regard to extreme weather events and natural hazards. The questionnaire was initially distributed to personal contacts (in a paper version), then produced in an online format available on the MOWE-IT website to allow a larger number of participants. The questionnaire offered closed questions, and allowed participants to expand with their own comments. A total of 58 respondents replied to the questionnaire. Participants belonged to transport organizations and operators, decision makers, transport and passenger associations, and civil protection agencies. Responses highlighted the necessity to prioritize the resilience of rail, local roads and air transport systems, as those sectors appear more vulnerable than others. In the views of respondents, extreme weather events have an impact on the whole supply chain, with clear effects on the food chain of agricultural and perishable products, and on passengers. In the respondents’ opinions, passengers should be more protected and safeguarded. They are often unable to take informed decisions before travelling, to switch from one transport mode to another if needed, and to monitor the transport situation while travelling. In general, the responses stressed that the transport system faces a very fragmented situation, because of the presence of national, regional and local authorities which, in some cases, are not harmonized and coordinated by a unique legislative framework. The lack of coordination is reflected also by transport operators and suppliers, who are incapable to exchange data and to establish inter-modality solutions that would protect passengers in case of emergencies. This fragmented scenario is accompanied by the need to update knowledge and studies on the impact of climate change and extreme weather events on transport, and therefore the necessity for policy makers to allocate additional funding and include transport resilience in their research agenda.

Shortly after, the vulnerability assessment of extreme events and natural hazards for the European passenger and freight transport chain was conducted. Impacts of extreme weather events (EWE) and natural hazards (NH) can impact transport flows directly through delays, accidents or by altering travel decisions. Indirect impacts can occur via damages to infrastructures or the enforcement of certain infrastructure operations blocking or reducing the capacity of transport networks. In front of this background, five dimensions of transport situations, user impacts and weather conditions were distinguished and elaborated in two steps: the estimation of clear weather costs and then the judgment of additional costs due to several degrees of severity of extreme weather events.

Figure 3: Impacts of extreme weather events on transport flows

Regarding the assessment of extreme events and natural hazards for the EU freight transport chain in the short-term, an extensive literature review was conducted in respect to the issue of vulnerability in freight transport, in an effort to highlight its various definitions, uses, applications and ways of quantifying. In addition, major freight routes that might be impacted from extreme weather events have been consolidated from previous research efforts (WEATHER and EWENT FP7 funded research projects) and a literature review was conducted on various extreme weather events and natural hazards affecting freight transport network operations at global, EU and regional/urban level. Finally, a specific case-study at regional/urban level has been selected for analyzing the impacts of extreme flooding on freight vehicle circulation (Attica flooding 2013) and the latter have been re-evaluated and re-assessed in light of the MOWE-IT developed roadmap of adaptation measures and policies addressing climate change – in the sense of how such an event would have impacted the freight transport networks, had a series of the suggested measures already been implemented. To improve the passengers’ and goods’ transport under the perspective of climate change, WP7 finally developed modal roadmaps for more resilient transport chains in passenger and freight transport. This contribution aimed at providing numerical estimates as well as discussions on the actual impact of severe weather events on passenger transport by modes, to support informed decisions on the transport sectors to be prioritized in terms of applying the roadmap. For the formulation of roadmaps, measures identified in the
individual modal guidebooks were prioritized, based on a multi-criteria analysis. Each measure was assessed accordingly in the following areas:

1. Time needed for the implementation of the measure
2. When should the measure be implemented?
3. What is the extent of financial resources needed for the implementation of the measure?
4. What is the extent of the measure (size of population influenced/benefited from a potential application)
5. How well does the measure contribute in the protection of transport infrastructure?
6. How well does the measure contribute in the perseverance of transport network operations?

The prioritization of the measures was based on the development of questionnaire survey that was conducted within the MOWE-IT consortium. Partners were asked to fill in the questionnaire, by assessing each measure in the areas described above and the indicative layout of the roadmap of road transport is presented in Figure 4.

Figure 4: Roadmap of actions for road transport

Long-term policy guidelines work package (WP8)

Work package 8 started at the beginning of the second year of the project. It was led by the Finnish Meteorological Institute (FMI). The aim of the work package is to produce policy guidelines which help to enhance and secure resilience in European transport networks and in aviation in particular. Its output is condensed in two Deliverables, D8.1 and D8.2. D8.1 concerns a research agenda to support and enable improvement of transport system resilience, whereas D8.2 presents a review of resilience performance, implemented policies and recommendations for new policies and measures.

Next to building on the collective knowledge of the consortium and the guidebooks, the work package reviewed trends in performance of aviation and other public transport modes in the EU and abroad, reviewed recent studies on effectiveness of policies, and assessed the tentative (maximum) potentials regarding cross-modal transfers. Apart from regular email contact coordination of activities was taken care of by means of WP specific skype meetings and a joint WP7/WP8 workshop in March 2014.

Results of the work package were presented in the regional dissemination conferences in September 2014. The very beneficial feedback and discussions during these conferences was used to finalize this Deliverables D82 and D81.

Finalisation of these deliverables was slightly delayed due to receiving some of the inputs from other work packages late and the tight schedule between final conferences and completion of the project. Deliverables 8.1 and 8.2 were submitted in October 2014.

The main findings reported in D8.1 and D8.2 are the following:

- When compared to other large aviation markets, such as the USA and China, delays in European aviation are somewhat less in percentage terms (US) or even significantly less (compared to China);
- Mandatory arrangements regarding compensation and care of stranded passengers is by and large somewhat more favourable for travellers in the EU as compared to US and Australia;
- Next to aviation only for rail systematic statistics on punctuality performance can be found, even though punctuality statistics for rail services still lack standardization and compilation of statistics at one point (of web access); in absolute numbers the amount of travellers affected by delays in aviation and HST/IC services respectively is quite comparable;
- The instigated customer protection regulation for travellers in public transport in EU Member Countries has had limited effect on the reduction of delay occurrences. Punctuality in rail services is largely driven by national public service contracts for rail companies. The protection regulation for air travel may have had some effect on the reduction of delays, but it seems that the costs of the regulation outweigh the benefits.
- The customer protection regulation can be still somewhat enhanced, notably by involving airports more broadly in the regulation;
- Spare capacity within the aviation system and in HST/IC services can offer notable but by no means complete relief in case of disruptions of aviation services at major airports; a growing number of major airports in Europe has high quality rail links; to make good use of the spare capacity both preparatory research and development in ICT services and in the regulatory framework of air and rail are necessary;
- Improvement of nowcasting services in case of convective storms, further sharing of information among actors, a day-ahead capacity projection tool (related to weather and other factors) in combination with scarce capacity allocation protocols, and intelligent (2-way) travel information & advice apps for travellers would further enhance the resilience of the aviation sector; all these activities entail research, product development and demonstration;
- Other helpful measures are the flexible use of military airspace allowing for civil co-use, aiming for good minimum ATC standards for all significant airports in Europe, filling in missing links in the HST system and offering extended HST services;
- It is important to create harmonized punctuality and performance statistics, with coverage of all significant modes;
• The valuation of spare capacity in cost-benefit analysis (and related evaluation approaches) needs to be reassessed in the light of resilience policy objectives;
• Create intermodal and cross-sector databases on incidents and risks and improve the knowledge base on intra- and inter-modal resilience and co-operation options;